MARSHALL MIX DESIGN METHOD FOR ASPHALTIC CONCRETE
(A Modification of AASHTO T 245 and ASTM D 1559)

Scope

1. This method is used to design asphaltic concrete mixes using Marshall apparatus. With some modifications this procedure may be used in designing other types of asphaltic concrete, such as recycled asphaltic concrete or emulsion mixes. It is not applicable to open graded mixtures such as Asphaltic Concrete Friction Course. (For ACFC Design see ARIZ Test Method 814).

Apparatus

2. The apparatus necessary includes all items required to perform the individual test methods referred to in this procedure.

Materials

3. (a) Mineral Aggregate - The mineral aggregate for the asphaltic concrete shall be produced material from the source(s) for the project. The mineral aggregate shall be tested for compliance to the project requirements for:

1) Gradation (ARIZ 201)

NOTE: The mineral aggregate shall meet specified composite gradation requirements when combined using desired percentages of the different produced materials. (See Section 4 for information regarding compositing samples.)

2) Sand Equivalent (AASHTO T 176)

3) Crushed Faces (ARIZ 212)

4) Abrasion (AASHTO T 96)

NOTE: The above tests may be added to or deleted as required by the specifications of the project.

NOTE: When the mix design is to be used for producing asphaltic concrete from a "batch plant" both bin material and stockpile material shall be used in developing the mix design as described in Sections 4 and 6.

(b) Bituminous Material - The asphalt used in the design shall be the asphalt which is to be used in the production of the asphaltic concrete. The specific gravity of the bituminous material shall be determined in accordance with AASHTO T 228.

(c) Mineral Admixtures - Any mineral admixtures which are required to achieve the requirements of the specified "Mix Design Criteria". This shall be the same type of material to be used on the project. Mineral admixtures shall conform to the requirements as set forth in the project specifications.

Determination of Composite Gradation

4. The composite gradation of the mineral aggregate is determined using desired percentages. When mineral admixture is used, the composite of mineral aggregate and mineral admixture is also determined. When mix designs are performed using bin material a composite of the bin material is performed using the desired percentages, along with a composite of the stockpile material which feeds the bins at the desired percentages. For designs developed using both bin material and stockpile material the composite gradation of the bin material is used for the design aggregate gradation.

NOTE: The sieve analysis for the aggregate from each individual stockpile or bin shall be determined in accordance with ARIZ 201. The Pass No. 4 fraction of each aggregate shall then be screened into No. 8 and Pass No. 8 sizes, and the weights for each recorded. The proportion of the Pass No. 4 fraction which passes the No. 8 sieve is determined by dividing the weight of Pass No. 8 material by the total weight of the No. 8 and Pass No. 8 material. This value is multiplied by the Pass No. 4 from the sieve analysis to determine the actual Pass No. 8, which is recorded to the nearest whole percent. This value is compared to the Pass No. 8 value from sieve analysis to provide a check on the representativeness of the fine sieve analysis. If the difference between the two Pass No. 8 values is greater than 4 the fine sieve analysis shall be adjusted by multiplying the percent pass for each sieve smaller than No. 8 by a factor obtained by dividing the actual Pass No.8 by the Pass No. 8 from sieve analysis.

(a) The compositing of aggregate materials is performed as described in ARIZ 205, "Composite Grading", with the following exceptions: (An example of a composite done for mix design is given in Figure 1, which shows the procedure outlined below.)

1) The Pass No 8 fraction is calculated for each type of aggregate by multiplying the % Pass No. 8 from the sieve analysis for the material by the "% of composite" that the type of aggregate represents and the total of each of the Pass No. 8 fractions is recorded as the "Composite of Pass No. 8 from Gradation of Each Stockpile or Bin".

2) The "Composite of Pass No. 8 From Gradation of Each Stockpile or Bin" is rounded to the whole % and recorded as the composite % Pass No 8. sieve.

3) Adjust fractions of material passing the No. 8 sieve for each type of aggregate as necessary to correspond to the value for each calculated % Pass No. 8.

4) After summing the % retained for each size fraction and rounding to the whole percent, any adjustments are made to the composite so that the calculated value for Pass No. 8 is not changed.

NOTE: If desired, the composite of aggregate materials may be adjusted using the method of "artificially grading" as shown in ARIZ 244.

(b) When mineral admixture is included in the mix the aggregate composite and gradation is adjusted to indicate the composite using the desired % mineral admixture "by weight of the aggregate". An example of the calculations is given in Figure 1.

1) The aggregate "% of composite" for each aggregate stockpile or bin is adjusted by the following:

$$\left[\begin{array}{c}\text{Adjusted}\\\text{Aggregate}\\\text{"\% of Composite"}\end{array}\right] = \frac{\text{Aggregate "\% of Composite"}}{100 + (\text{\% mineral admixture})} \quad X \quad 100$$

Example (for coarse aggregate and 2% mineral admixture):

$$\left[\begin{array}{c}\text{Adjusted}\\\text{Aggregate \% of}\\\text{Composite}\end{array}\right] = \frac{26}{100 + 2} \quad X \quad 100 = 25.49\% = 25\%$$

2) The percentage of mineral admixture in the adjusted composite is determined:

$$\left[\begin{array}{c}\text{Adjusted}\\\text{\% Mineral}\\\text{Admixture}\end{array}\right] = \frac{\text{\% mineral admixture}}{100 + (\text{\% of mineral admixture})} \quad x \quad 100$$

Example (For 2% mineral admixture):

$$\text{Adjusted \% mineral admixture} = \frac{2}{100 + 2} \; x \; 100 = 1.96\% = 2\%$$

3) The aggregate gradation (for % passing) is adjusted for mineral admixture by performing the following calculation for each sieve:

$$\left[\begin{array}{c}\text{Adjusted}\\\text{\% Pass}\\\text{Each Sieve}\end{array}\right] = \frac{\left[\begin{array}{c}\text{\% Pass}\\\text{From Aggregate}\\\text{Composite}\end{array}\right] + \left[\begin{array}{c}\text{\% Mineral}\\\text{Admixture}\end{array}\right]}{100 + (\text{\% of mineral admixture})} \quad X \quad 100$$

Example (For No. 16 sieve):

$$\text{Adjusted \% Pass} = \frac{36 + 2}{100 + 2} \; x \; 100 = 37.25\% = 37\%$$

4) The % retained on each sieve is determined:

$$\left[\begin{array}{c}\text{\% Retained}\\ \text{on}\\ \text{Each Sieve}\end{array}\right] = \left[\begin{array}{c}\text{\% passing}\\ \text{next larger}\\ \text{sieve size}\end{array}\right] - \left[\begin{array}{c}\text{\% passing}\\ \text{desired}\\ \text{sieve size}\end{array}\right]$$

Example (For 1/4" sieve):

% retained = 78% - 67% = 11%

(c) The composited gradation of the aggregate (and composite of aggregate and mineral admixture when used) is shown on the design card, along with the percentage of each material.

Preparing Samples for Mix Designs Using Stockpile Material

5. The samples necessary in the design are prepared and weighed up for testing utilizing the stockpile composite information.

(a) Representative samples, for each size fraction in the composite, are obtained for the tests necessary in the design. The size fractions which shall be utilized are individual sizes from each stockpile for material of No. 8 sieve size and larger, and minus No. 8 material from each stockpile. A weigh up sheet is shown in Figure 2, which gives an example illustrating the use of the composite information and the material sizes required.

NOTE: If the composite was accomplished using the "artificial grading" method, the preparation of samples will be as directed in ARIZ 244.

(b) The aggregate sample sizes, number of samples required for design tests, and other pertinent information in preparing the samples are given in Section 7.

Preparing Samples for Mix Designs Using Bin Material

6. When bin material is used for the mix design the samples are prepared and weighed up for testing as outlined below.

(a) The stockpile composite gradation shall be adjusted to the desired gradation of the bin composite. This is accomplished as outlined in ARIZ 244.

(b) Representative samples of bin material, for each size fraction in the bin composite, are obtained for performing the Marshall Stability/Flow and Density tests. Size fractions to be used are individual sizes from each bin for material of No. 8 sieve size and larger, and Pass No. 8 material from each bin.

(c) Representative samples of stockpile material, using the adjusted composite information obtained from "artificially grading" in ARIZ 244, are obtained for performing all other required tests (Sand Equivalent, Crushed Faces, Abrasion, Fine and Coarse Aggregate Specific Gravity/Absorption, Rice Test, and

Immersion Compression Test). The size fractions to be used are individual sizes from each stockpile for material of No. 8 sieve size and larger; and for the Pass No. 8 material, the amount of each size fraction for Pass No. 8 to Retained No. 40, Pass No. 40 to Retained No. 200, and Pass No. 200. An illustration of the use of the above size fractions is shown in Figure 4 of ARIZ 244.

(d) The aggregate sample sizes, number of samples required for design tests, and other pertinent information in preparing the samples are given in Section 7.

Aggregate Sample Sizes

7. (a) The following table gives the aggregate samples sizes and the number of samples required for each test. The aggregate weight shown below for Maximum Theoretical Specific Gravity will provide 3 test samples, the amount shown for Density-Stability/Flow will produce 3 Marshall specimens and the weight for Immersion Compression will produce 2 specimens.

Test	Aggregate Sample Size	Number of Samples
Fine Aggregate Specific Gravity/ Absorption	1200 grams	1
Coarse Aggregate Specific Gravity/Absorption	*	1
Maximum Theoretical Specific Gravity (Rice Test)	3000 grams	1
Density-Stability/Flow	**3300 grams	***
Immersion Compression	**3400 grams	3

* Minimum weight of the test sample is determined by nominal maximum size of the aggregate, in accordance with AASHTO T 85.

** Generally the weight shown will provide specimens of acceptable heights, but adjustments may be necessary in some cases. If the combined specific gravity of the coarse and fine mineral aggregate is known, the following equation will normally provide specimens within the specified criteria:

$$\left[\begin{array}{c}\text{Adjusted}\\ \text{Weight of}\\ \text{Aggregate}\end{array}\right] = \frac{\left[\begin{array}{c}\text{Combined Bulk O.D.}\\ \text{Agg. Specific Gravity}\end{array}\right]}{2.650} \times \left[\begin{array}{l}\text{Approx. Sample Size}\\ \text{Shown (3300 grams for}\\ \text{Density-Stability/Flow}\\ \text{and 3400 grams for}\\ \text{Immersion Compression)}\end{array}\right]$$

*** 1 Sample for each asphalt content desired to be tested.

NOTE: When mineral admixture is used, the proper amount is added to the composited aggregate samples for Density-Stability/Flow and Immersion Compression specimens only. The mineral admixture and aggregate shall be thoroughly mixed together.

Aggregate Specific Gravities and Absorption

8. (a) The Bulk Oven Dry, S.S.D., Apparent specific gravities and absorption of the fine and coarse mineral aggregate shall be determined in accordance with ARIZ 211 and AASHTO T 85 respectively.

NOTE: When different sources of fine mineral aggregate are to be used in the production of asphaltic concrete the specific gravity and absorption of each individual fine material shall be determined and recorded and the combined specific gravity and absorption calculated as specified in ARIZ 211. This allows for the combining of fine aggregates in varying amounts without having to composite a sample of the different sources and testing the combined materials. If "artificial grading" has been performed, the fine aggregate specific gravity and absorption shall be determined on a sample of the combined material from the different sources.

(b) The combined Bulk Oven Dry, S.S.D., Apparent specific gravities and combined absorption for the coarse and fine mineral aggregate are calculated by the following:

$$\left[\begin{array}{c}\text{Combined}\\ \text{Specific}\\ \text{Gravity}\end{array}\right] = \frac{100}{\dfrac{Pc}{Gc} + \dfrac{Pf}{Gf}}$$

Where: Pc and Pf = weight percent of coarse aggregate (Plus No. 4) and fine aggregate (Minus No. 4) respectively. (Note the Pc and Pf are for aggregate material only. If mineral admixture is being used in the design, Pc and Pf shall be determined for composite of mineral aggregate only, not for the aggregate and mineral admixture composite.)

Gc and Gf = specific gravity of coarse and fine aggregate respectively.

Example (For combined S.S.D. specific gravity):

$$\left[\begin{array}{c}\text{Combined}\\ \text{S.S.D.}\\ \text{Specific Gravity}\end{array}\right] = \frac{100}{\dfrac{41}{2.597} + \dfrac{59}{2.626}} = 2.614$$

$$\text{Combined Absorption} = \frac{\left[\begin{array}{c}\text{Combined S.S.D.}\\ \text{Specific Gravity}\end{array}\right] - \left[\begin{array}{c}\text{Combined Bulk O.D.}\\ \text{Specific Gravity}\end{array}\right]}{(\text{Combined Bulk O.D. Specific Gravity})} \times 100$$

Example: (Combined S.S.D. Sp. Gr. = 2.614, Combined Bulk O.D. Sp. Gr. = 2.576)

$$\text{Combined Absorption} = \frac{2.614 - 2.576}{2.576} \times 100 = 1.48\%$$

Preparation of Specimens for Density and Stability/Flow Determination

9. Specimens shall be prepared as follows, using apparatus shown in AASHTO T 245.

NOTE: Paragraph 2.4 of AASHTO T 245 shall be changed to read: "Compaction pedestal - The compaction pedestal shall consist of an 8" by 8" by 18" wooden post capped with a 12" by 12" by 1" steel plate. The steel cap shall be firmly fastened to the post. The wooden post shall have a dry weight of 42 to 48 lbs./cu. ft. and shall rest squarely on a solid concrete slab and shall be secured by four angle brackets to the concrete slab. The pedestal assembly shall be installed so that the post is plumb and the cap is level."

NOTE: If a mechanical hammer is utilized to compact specimens, generally results which are within 0.5 lbs./cu. ft. of hand hammer results are considered acceptable.

(a) The temperature of the asphalt and aggregate at the time mixing begins shall be in accordance with the following:

Asphalt Grade	Temperature
AC 20	300 ± 10 F.
AC 30, AC 40	305 ± 10 F.

(b) The aggregate (and mineral admixture when used) shall be dried to constant weight at the temperature required as shown in paragraph 6 (a). Bring samples to desired weight by adding a small amount of proportioned Pass No. 8 make up material.

NOTE: Normally a range of 1% asphalt, or 3 different asphalt contents at 0.5% increments will provide sufficient information, although in some cases it may be necessary to prepare additional sets of samples at other asphalt contents.

(c) The aggregate (and mineral admixture when used) and asphalt shall be mechanically mixed for 90 to 120 seconds in a commercial dough mixer with a minimum 10 quart capacity and equipped with a wire whip and then hand mixed as necessary to ensure thorough coating.

NOTE: Before each batch is mixed, the mixing bowl and whip shall be at approximately the temperature specified in paragraph 6 (a).

(d) Each mixed sample shall be placed on a tarp or sheet of heavy paper and in a rolling motion thoroughly mixed. The material shall be spread into a circular mass 1 1/2 to 2 inches thick. The circular mass shall be cut into 6 equal segments, taking opposite segments for each individual sample.

(e) Each sample shall be placed in a pan and allowed to cure for 2 hours ± 10 minutes at approximately 285 F. A mold assembly (baseplate, mold and collar) shall be heated to approximately 285 F. The face of the compaction hammer shall be thoroughly cleaned and heated on hot plate set at approximately 285 F.

(f) Place a 4" paper disc in the bottom of the mold before the mixture is introduced. Place the entire batch in the mold with a heated spoon. Spade the mixture vigorously with a heated flat metal spatula, with a blade approximately 1" wide and 6" long and stiff enough to penetrate the entire layer of material, 15 times around the perimeter and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Smooth the surface of mix to a slightly rounded shape.

(g) Before compaction the mixture shall be at the proper temperature as shown below for the grade of asphalt being used.

Asphalt Grade	Temperature
AC 20	280 ± 10 F.
AC 30, AC 40	285 ± 10 F.

NOTE: To maintain compaction temperature the mixture and mold may be returned to the oven before compaction.

(h) Place paper disc on top of material, place the mold assembly on the compaction pedestal in the mold holder, and apply 75 blows with the compaction hammer. Remove the base plate and collar, and reverse and reassemble the mold. Apply the same number of compaction blows to the face of the reversed specimen.

NOTE: The compaction hammer shall apply only one blow after each fall, that is, there shall not be a rebound impact.

(i) Remove collar, baseplate, paper discs and allow specimen to cool.

NOTE: Cooling may be accomplished at room temperature, in a 77 F. air bath, or if more rapid cooling is desired the mold and specimen may be placed in front of a fan until cool.

(j) Extrude the specimen from the mold.

NOTE: Care shall be taken in extruding the specimen from the mold, so as not to develop tensile stresses in the specimen.

(k) Measure the height of the specimen to the nearest 0.001 inch.

NOTE: Compacted specimens shall be 2.50 ± 0.20 inches in height. If this criteria is not met for the specimens at each asphalt content the entire set of specimens at that asphalt content shall be discarded and a new set prepared after necessary adjustments in the aggregate weight have been made.

(l) Follow the procedure in paragraphs (f) through (k) for all specimens required.

Specific Gravity/Bulk Density of Specimens

10. (a) Determine the specific gravity of the three specimens at each asphalt content in accordance with ARIZ 415, Method A. The determination of the "Weight in Water" and "S.S.D. Weight" of each specimen will be completed before the next specimen is submerged for its "Weight in Water" determination.

NOTE: Specimens are assumed to be at constant weight after extrusion from the molds.

(b) Determine the density in lbs./cu. ft., by multiplying the specific gravity of each specimen by 62.3 lbs./cu. ft.

NOTE: For each asphalt content the densities shall not differ by more than 2.0 lbs./cu. ft. If this density requirement is not met the entire set of specimens at that asphalt content shall be discarded and a new set of specimens prepared.

Stability and Flow Determination

11. The stability and flow of each specimen shall be determined as follows:

(a) Bring the specimens to 140 ± 1.8 F. by immersing in water bath 30 to 40 minutes. The specimens shall be supported on a plate (a 5" x 5" glass plate is ideal) during the immersion period and while removing from the bath. Thoroughly clean the guide rods and the inside of the test heads prior to running the test, and lubricate the guide rods so that the upper test head slides freely over them. The testing head temperature shall be maintained between 70 and 100 F., using a water bath when required. Remove the specimen from the water bath, quickly towel dry the specimen and place it in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen, and place the complete assembly in position on the testing machine.

(b) Place the flowmeter in position over one of the guide rods and adjust the flowmeter to zero while holding the sleeve firmly against the upper segment of the breaking head. Hold the flowmeter sleeve firmly against the upper segment of the breaking head while the test load is being applied.

NOTE: In lieu of adjusting the flowmeter to zero, the beginning reading may be subtracted from the ending reading to determine the flow.

(c) Apply the load to the specimen by means of the constant rate of the load jack or testing machine head of 2 inches per minute until the maximum load is reached and the load decreases as indicated by the proving ring micrometer dial. Record the maximum micrometer dial reading and also the flow reading the instant the maximum load is determined. The elasped time for the test from removal of the test specimen from the water bath to maximum load determination shall not exceed 30 seconds.

NOTE: The maximum load is defined as the last point in the load/time curve before the load decreases.

(d) The micrometer dial reading shall be converted to load in pounds (stability) using the calibration chart provided for the proving ring, or a formula derived from the calibration chart.

NOTE: Some testing machines, which are operated in a different manner than described in paragraphs (b) through (d), are capable of providing a direct stability/flow reading. When utilizing this type of apparatus, refer to the operation manual for the equipment to determine readings for stability and flow.

(e) Record the stability of each specimen to the nearest pound and the flow to the nearest 0.01 inch.

(f) Correct the stability obtained for each specimen for the height of the specimen by the following table:

STABILITY CORRELATION RATIOS*

Height of Specimen (Inches)	Correlation Ratio
2.300 - 2.306	1.15
2.307 - 2.319	1.14
2.320 - 2.332	1.13
2.333 - 2.344	1.12
2.345 - 2.357	1.11
2.358 - 2.369	1.10
2.370 - 2.381	1.09
2.382 - 2.393	1.08
2.394 - 2.405	1.07
2.406 - 2.417	1.06
2.418 - 2.430	1.05
2.431 - 2.445	1.04
2.446 - 2.461	1.03
2.462 - 2.477	1.02
2.478 - 2.492	1.01
2.493 - 2.507	1.00
2.508 - 2.522	0.99
2.523 - 2.537	0.98
2.538 - 2.553	0.97
2.554 - 2.573	0.96
2.574 - 2.594	0.95
2.595 - 2.615	0.94
2.616 - 2.634	0.93
2.635 - 2.649	0.92
2.650 - 2.663	0.91
2.664 - 2.679	0.90
2.680 - 2.697	0.89
2.698 - 2.700	0.88

* The measured stability of a specimen multiplied by the ratio for the height of the specimen equals the corrected stability for a 2-1/2 inch specimen.

(g) Determine and record the average values for stability and flow for each asphalt content.

NOTE: An example of the recorded results for density determination, stability/flow, and the corrected stability values is shown in Figure 3.

(h) Compare resultant stability and flow values with the mix design criteria or governing specification requirements and determine if acceptable results have been obtained, if the design should be discarded, or if additional specimens at other asphalt contents should be prepared and tested for density, stability and flow.

Maximum Theoretical Specific Gravity (Rice Test)

12. The maximum specific gravity of the mixture shall be determined in accordance with ARIZ 806. Values obtained from the Rice Test are utilized in the Voids Relationships calculations to determine the "asphalt lost by absorption into aggregate expressed as the % by weight of the dry aggregate".

Determination of Design Asphalt Content

13. The design asphalt content is determined as follows in paragraphs (a) through (e).

(a) For each asphalt content used, determine values for voids relationships required by the specifications in accordance with the "Method for Determining Void Relationships in Asphaltic Paving Mixtures" (Figures 4 through 7).

NOTE: The calculations for determining the voids relationships include the necessary equations when mineral admixtures are used. An example of the calculations with mineral admixture, are given in Figures 8 and 9.

(b) If a range of asphalt contents have been tested, the calculated specific gravity shall be determined for desired asphalt contents by interpolating between the values obtained for the specific gravity in Section 8.

(c) Using the interpolated specific gravities, determine the bulk density and voids relationships at each corresponding asphalt content.

(d) The design asphalt content shall be the asphalt content which meets all specified requirements, and provides air voids as close to the middle of the range given in the specified Mix Design Criteria as possible.

NOTE: If it is not possible to obtain acceptable results within the range of asphalt contents used, a determination must be made as to either discarding the design or preparing additional specimens at other asphalt contents for density, stability/flow testing and voids relationships analysis.

(e) Interpolate the value for Stability and Flow at the selected design asphalt content. Check these values against the design criteria for acceptability.

NOTE: If the average stability and/or flow of tested specimens for an asphalt percent used in the interpolation of the design asphalt content is outside the specification limits, a set of 3 specimens shall be prepared at the selected design asphalt content and tested for Bulk Density and Stability/Flow, along with the determination of voids relationships. The resultant values are then checked for compliance to specified requirements.

(f) Calculate the maximum theoretical density for the design asphalt content by the equation below. This value is recorded on the design card as shown in Figure 10.

$$\text{Maximum Density} = \frac{\text{Bulk Density}}{100 - \%\ \text{Air Voids}} \times 100$$

Immersion Compression Test

14. Using the design asphalt content, perform the Immersion Compression test in accordance with ARIZ 802.

Mix Design Gradation Target Values

15. The desired target values for the aggregate (and mineral admixture when used) in the bituminous mixture shall be from the composited gradation and shall be expressed as percent passing particular sieve sizes as required by the specifications for the project.

NOTE: The target values for aggregate (and also aggregate with mineral admixture, when used) are shown on the design card. The gradation of samples taken for specification compliance are compared to the applicable target values, (e.g., a mix design requires mineral admixture and the mineral admixture is blended with the asphalt. The sample for specification compliance will be aggregate only and therefore is compared to the target values given without cement).

Report and Example

16. Report the test results and data obtained along with the "Recommended Bitumen Content Considering All Test Data" on the Laboratory Bituminous Mixture Design card, as shown in the example in Figure 10. Liberal use of the remarks area to clarify and/or emphasize any element of the design is recommended.

DATE 8-15-85 PROJECT NO. F-099-9(11) LAB. NO. 85-999B DESIGN 1/2" AC

Sieve Size	Aggregate "% of composite"	999 C 26%	998 I 12%	997 F 47%	996 B 15%		% Ret.	% Ret. Rounded	% Pass	Design Specs.
1"										
3/4"									100	100
1/2"		4.4					4.4	4	96	90-100
3/8"		~~16.4~~ 16.3	1.4				17.7	18	78	70-85
1/4"		4.4	~~6.6~~ 6.7	0.9	0.2		12.2	12	66	
#4		0.3	3.2	3.3	0		6.8	7	59	
#8		0.3	0.5	10.8	1.2		12.8	13	46	43-51
#10		0	0	2.4	0.8		3.2	3	43	
#16		0	0	4.7	2.7		7.4	7	36	
#30		0	0	~~6.6~~ 6.5	~~4.4~~ 4.3		10.8	11	25	
#40		0	0	3.8	2.1		5.9	6	19	12-22
#50		0	0	3.3	1.6		4.9	5	14	
#100		0	0	4.7	1.4		6.1	6	8	
#200		~~0~~ 0.1	0	2.8	0.3		3.2	3	4.6	2.0-6.0
Pass #200		0.18	0.24	3.81	0.40		4.63	4.6		

MIX DESIGN CRITERIA REQUIREMENTS:

IMC RET. ~ 50%
MIN. WET STRENGTH ~ 150
VOIDS ~ 5.0-7.0
V.M.A. ~15.5-18.5
MIN. STABILITY ~ 2000
FLOW ~ 8-16

COMPOSITE OF PASS NO. 8 FROM GRADATION OF EACH STOCKPILE OR BIN:

LAB #	-#8
999	0.3
998	0.2
997	32.0
996	13.6

TOTAL = 46.1

Sieve Size	Adjusted "% of composite" for use of mineral admixture	C 25%	I 12%	F 46%	B 15%	T-II 2%	Calc. % Pass	% Ret.	% Pass	Design Specs.
	Adjusted "% of composite" =	Adjusted "% of composite" = 25.49	Adjusted "% of composite" = 11.76	Adjusted "% of composite" = 46.08	Adjusted "% of composite" = 14.71	Adjusted % Mineral Admix. = 1.96				
1"										
3/4"									100	100
1/2"							96.08	4	96	90-100
3/8"							78.43	18	78	70-85
1/4"							66.67	11	67	
#4							59.80	7	60	
#8							47.06	13	47	44-52
#10							44.12	3	44	
#16							37.25	7	37	
#30							26.46	11	26	
#40							20.59	5	21	13-23
#50							15.69	5	16	
#100							9.80	6	10	
#200							6.47	4	6.5	3.0-7.5

REMARKS

FIGURE 1

44-9361 10/83

ASPHALTIC CONCRETE MIX DESIGN WEIGH UP CARD

MATERIAL 1/2" AC LAB NO. 85-999B DATE 8-15-85

PROJECT NO. F-099-9(11) PROJECT NAME CHRISTMAS CANYON - CLAUS T.I.

CONTRACTOR REINDEER CONTRACTING MIX DESIGN REQUEST #2

			1	3	3	1	1	1				1	1	1	1	1		
LAB NO.	SIZE	ACCUM % RET.	RICE	STABS	IMC	COARSE SP. GR.	COARSE SAND EQUIV.	CRUSH. FACES	COARSE C.K.E.	LIME-STONE	FLAKI-NESS INDEX	ABRASION "B"	BLEND SP. GR.	FINE SAND EQUIV.	FINE SP. GR.	- #8 MAKE-UP MAT'L	SIZE	LAB NO.
999	1/2	4.4	132	141	145	321	45	24				2500						
	3/8	20.7	621	664	684	1511	211	115				4802						
	1/4	25.1	753	805	830	1832	256	140				—						
	#4	25.4	762	815	839	1854	259	~~141~~				—						
998	3/8	26.8	804	860	886	1956	273	149				5000						
	1/4	33.5	1005	1075	1107	2445	341	186										
	#4	36.7	1101	1177	1213	2679	374	204										
997	1/4	37.6	1128	1206	1243	2745	383	209										
	#4	40.9	1227	1312	1352	2985	417	228										
996	1/4	41.1	1233	1318	1358	3000	~~419~~	~~229~~										
999	#8	41.4	1242	1328	1368			230					—	3	8	—	#8	999
998	#8	41.9	1257	1344	1385			233					—	8	22	—	#8	998
997	#8	52.7	1581	1691	1742			293					—	118	316	—	#8	997
996	#8	53.9	1617	1729	1781			300					97	130	—	—	#8	996
999	-#8	54.2	1626	1739	1791								—	133	324	4	-#8	999
998	-#8	54.4	1632	1745	1798								—	135	329	7	-#8	998
997	-#8	86.4	2592	2772	2856								—	461	1200	423	-#8	997
996	-#8	100	3000	3208	3305								1200	600		600	-#8	996
2% TYPE II		CEMENT -		3272	3371													

ADJUSTED AGG. WEIGHT FOR STABS. = (2.576 / 2.650) x 3300 = 3208

ADJUSTED AGG. WEIGHT FOR IMC'S = (2.576 / 2.650) x 3400 = 3305

REMARKS:

FIGURE 2

LAB # 85-999B PROJ. # F-099-9(11) DATE 8-16-85 SP. GR. = $\frac{\text{AIR}}{\text{SSD-H20}}$ DENSITY= (SP.GR.)X(62.3)

% ASPH.	ADMIXTURE	PLUG #	HVEEM/ MARSHALL	SSD WT.	H20 WT.	AIR WT.	SPECIFIC GRAVITY	DENSITY #/FT3	PLUG HEIGHT	STABILITY	CORR. RATIO	CORR. STABILITY	FLOW
4.5	2% TYPE II	1	M	1135.5	637.6	1131.2	2.272	141.5	2.540	4020	0.97	3899	11
		2		1136.9	638.1	1126.7	2.259	140.7	2.583	3810	0.95	3620	11
		3		1139.4	641.5	1134.3	2.278	141.9	2.555	4520	0.96	4339	12

AVG. SP. GR. & CALC. DENS. 2.270 141.4 AVG. STAB. & FLOW 3953 11

DENS. RANGE 1.2

% ASPH.	ADMIXTURE	PLUG #	HVEEM/ MARSHALL	SSD WT.	H20 WT.	AIR WT.	SPECIFIC GRAVITY	DENSITY #/FT3	PLUG HEIGHT	STABILITY	CORR. RATIO	CORR. STABILITY	FLOW
5.0	2% TYPE II	4	M	1137.8	645.9	1136.4	2.310	143.9	2.511	4710	0.99	4663	13
		5		1145.1	645.7	1143.6	2.290	142.7	2.558	4090	0.96	3926	12
		6		1149.0	645.8	1147.9	2.281	142.1	2.568	3820	0.96	3667	11

AVG. SP. GR. & CALC. DENS. 2.294 142.9 AVG. STAB. & FLOW 4085 12

DENS. RANGE 1.8

% ASPH.	ADMIXTURE	PLUG #	HVEEM/ MARSHALL	SSD WT.	H20 WT.	AIR WT.	SPECIFIC GRAVITY	DENSITY #/FT3	PLUG HEIGHT	STABILITY	CORR. RATIO	CORR. STABILITY	FLOW
5.5	2% TYPE II	7	M	1161.1	657.7	1159.8	2.304	143.5	2.536	4140	0.98	4057	11
		8		1151.2	655.6	1147.9	2.316	144.3	2.516	4480	0.99	4435	12
		9		1146.9	655.2	1145.2	2.329	145.1	2.512	4880	0.99	4831	12

AVG. SP. GR. & CALC. DENS. 2.316 144.3 AVG. STAB. & FLOW 4441 12

CHECKED BY FD

DENS. RANGE 1.6

FIGURE 3

Oven dry bulk specific gravity of coarse aggregate by AASHTO T 85 and fine aggregate by ARIZ 211

Coarse Aggregate (Gc)

$$\frac{\left(\text{Weight of oven dry sample in air (A)}\right)}{\left(\text{Weight of S.S.D. sample in air (B)}\right) - \left(\text{Weight of saturated sample in water (C)}\right)}$$

Fine Aggregate (Gf)

$$\frac{\left(\text{Oven dry weight of 500 g. S.S.D. sample (A)}\right)}{\left(\text{Weight of flask filled with water (B)}\right) + \left(\text{500 grams = weight of S.S.D. sample}\right) - \left(\text{Weight of flask} + \text{500 g. S.S.D. sample} + \text{water to fill (C)}\right)}$$

Combined Bulk O.D. specific gravity of aggregate

Gsb

$$\frac{(100)}{\dfrac{\left(\text{\% coarse aggregate (Pc)}\right)}{\left(\text{Bulk O.D. specific gravity of coarse aggregate (Gc)}\right)} + \dfrac{\left(\text{\% fine aggregate (Pf)}\right)}{\left(\text{Bulk O.D. specific gravity of fine aggregate (Gf)}\right)}}$$

Measured maximum specific gravity of bituminous mixture by ARIZ 806

$$\text{Volume of voidless mix (Vvm)} = \left(\text{Weight of mix sample (Wmm)*}\right) + \left(\text{Weight of flask filled with water (B)}\right) - \left(\text{Weight of flask with mix sample, filled with water after evacuation of air (C)}\right)$$

* If aggregate has absorbed water, the surface dry weight (Wsd) shall replace (Wmm) in the above equation.

$$\text{Maximum specific gravity of bituminous mixture (Gmm)} = \frac{\left(\text{Weight of mix sample (Wmm)}\right)}{\left(\text{Volume of voidless mix (Vvm)}\right)}$$

FIGURE 4

Effective specific gravity of aggregate

Gse

$$\frac{\left(\text{Weight of aggregate in mix sample (Wmm x \% aggregate x 0.01)}\right)}{\left(\text{Volume of voidless mix (Vvm)}\right) - \left[\dfrac{\left(\text{Weight of asphalt in mix sample (Wmm x \% asphalt x 0.01)}\right)}{\left(\text{Specific gravity of asphalt (Gb)}\right)}\right]}$$

Asphalt lost by absorption into aggregate expressed as % by weight of dry aggregate

Pba

$$\left[\frac{\left(\text{Effective specific gravity of aggregate (Gse)}\right) - \left(\text{Combined bulk O.D. specific gravity of aggregate (Gsb)}\right)}{\left(\text{Effective specific gravity of aggregate (Gse)}\right) \times \left(\text{Combined bulk O.D. specific gravity of aggregate (Gsb)}\right)}\right] \times \left(\text{Specific Gravity of asphalt (Gb)}\right) \times (100)$$

Average Measured Bulk Specific Gravity of specimens by AASHTO T 166

Gmb

$$\frac{\left(\text{Weight of specimen in air (A)}\right)}{\left(\text{Weight of surface dry specimen in air (B)}\right) - \left(\text{Weight of specimen in water (C)}\right)}$$

Note: The following equations provide the volume relationships for mixes with or without mineral admixtures.

% Mineral Aggregate in mix

Pma

$$\frac{\left((100) - \text{\% asphalt in mix (Pb)}\right)}{1.00 + \left[(0.01) \times \left(\text{\% mineral admixture by weight of aggregate (Pad)}\right)\right]}$$

% Mineral Admixture in Mix

Pmx

$$\left(100 - \text{\% asphalt in mix (Pb)}\right) - \left(\text{\% aggregate in mix (Pma)}\right)$$

FIGURE 5

Volume of Aggregate

Vag

$$\frac{\left(\text{\% aggregate in mix (Pma)}\right) \times \left(\text{Average Measured Bulk specific gravity of specimens (Gmb)}\right)}{\left(\text{Combined Bulk O.D. specific gravity of aggregate (Gsb)}\right)}$$

Volume of Mineral Admixture

Vmx

$$\frac{\left(\text{\% mineral admixture in mix (Pmx)}\right) \times \left(\text{Average Measured Bulk specific gravity of specimens (Gmb)}\right)}{\left(\text{Specific Gravity of Mineral Admixture (Gad)}\right)}$$

Effective asphalt content, % of total mix

Pbe

$$\left(\text{\% asphalt in mix (Pb)}\right) - \left[\left(\text{Asphalt lost by absorption into aggregate expressed as \% by weight of dry aggregate (Pba)}\right) \times \left(\text{\% aggregate in mix (Pma)}\right) \times (0.01)\right]$$

Volume of Effective Asphalt

Vbe

$$\frac{\left(\text{Effective Asphalt Content, \% of Total mix (Pbe)}\right) \times \left(\text{Average Measured Bulk Specific Gravity of Specimens (Gmb)}\right)}{\left(\text{Specific Gravity of Asphalt (Gb)}\right)}$$

FIGURE 6

% Voids in Mineral Aggregate VMA	$(100) - \left(\begin{array}{l}\text{Volume of}\\ \text{Aggregate (Vag)}\end{array}\right) - \left(\begin{array}{l}\text{Volume of Mineral}\\ \text{Admixture (Vmx)}\end{array}\right)$

Note: If a mineral admixture is used, VMA is the voids in the combination of mineral aggregate and mineral admixture, as indicated by the above equation.

% Effective air voids EV	$\left(\begin{array}{l}\text{Voids in mineral}\\ \text{aggregate (VMA)}\end{array}\right) - \left(\begin{array}{l}\text{Volume of Effective}\\ \text{Asphalt (Vbe)}\end{array}\right)$
% of voids in mineral aggregate filled with asphalt VF	$\left[\dfrac{\left(\text{Volume of Effective Asphalt (Vbe)}\right)}{\left(\text{Voids in mineral aggregate (VMA)}\right)}\right] \times (100)$

FIGURE 7

I. Calculation of Combined Aggregate Bulk O.D. Specific Gravity:

$$Gsb = \frac{100}{\frac{Pc}{Gc} + \frac{Pf}{Gf}} = \frac{100}{\frac{(41)}{(2.558)} + \frac{(59)}{(2.589)}} = 2.576$$

II. Data obtained from Rice Test:

Vvm = 442.5

Gmm = 2.392 ; Gmm x 62.3 = (2.392) x 62.3 = 149.0 lb./cu. ft.

$$Gse = \frac{(Wmm \times \%\ aggregate \times 0.01)}{Vvm - \left[\frac{(Wmm \times \%\ asphalt \times 0.01)}{Gb}\right]} = \frac{(1058.4) \times (94.0) \times (0.01)}{(442.5) - \left[\frac{(1058.4) \times (6.0) \times (0.01)}{(1.023)}\right]} = 2.615$$

$$Pba = \frac{Gse - Gsb}{Gse \times Gsb} \times Gb \times 100 = \frac{(2.615) - (2.576)}{(2.615) \times (2.576)} \times (1.023) \times 100 = 0.59\ \%$$

III. Recorded Average Measured Bulk Specific Gravity of Specimen at each asphalt content tested:

Gmb @ Pb = 4.5 %: (2.270); Gmb x 62.3 = (2.270) x 62.3 = 141.4 lb./cu. ft.

Gmb @ Pb = 5.0 %: (2.294); Gmb x 62.3 = (2.294) x 62.3 = 142.9 lb./cu. ft.

Gmb @ Pb = 5.5 %: (2.316); Gmb x 62.3 = (2.316) x 62.3 = 144.3 lb./cu. ft.

IV. MINERAL ADMIXTURE SPECIFIC GRAVITIES:

TYPE II CEMENT = 3.14
TYPE IP CEMENT = 3.00
LIME = 2.20

V. Calculations of Voids Relationships

Pb = 4.5%

$$Pma = \frac{(100 - Pb)}{1.00 + (0.01 \times Pad)} = \frac{(100) - (4.5)}{1.00 + \left[(0.01) \times (2.0)\right]} = 93.63$$

$$Pmx = (100 - Pb) - Pma = \left[100 - (4.5)\right] - (93.63) = 1.87$$

$$Vag = \frac{Pma \times Gmb}{Gsb} = \frac{(93.63) \times (2.270)}{(2.576)} = 82.51$$

$$Vmx = \frac{Pmx \times Gmb}{Gad} = \frac{(1.87) \times (2.270)}{(3.14)} = 1.35$$

$$Pbe = Pb - (Pba \times Pma \times 0.01) = (4.5) - \left[(0.59) \times (93.63) \times (0.01)\right] = 3.95$$

$$Vbe = \frac{Pbe \times Gmb}{Gb} = \frac{(3.95) \times (2.270)}{(1.023)} = 8.76$$

$$VMA = 100 - Vag - Vmx = 100 - (82.51) - (1.35) = 16.14$$

$$EV = VMA - Vbe = (16.14) - (8.76) = 7.38$$

$$VF = \frac{Vbe}{VMA} \times 100 = \frac{(8.76)}{(16.14)} \times 100 = 54.28$$

FIGURE 8

$$Pma = \frac{(100 - Pb)}{1.00 + (0.01 \times Pad)} \qquad Pmx = (100 - Pb) - Pma \qquad Vag = \frac{Pma \times Gmb}{Gsb}$$

$$Vmx = \frac{Pmx \times Gmb}{Gad} \qquad Pbe = Pb - (Pba \times Pma \times 0.01) \qquad Vbe = \frac{Pbe \times Gmb}{Gb}$$

$$VMA = 100 - Vag - Vmx \qquad EV = VMA - Vbe \qquad VF = \frac{Vbe}{VMA} \times 100$$

Pb = 5.0 %

$$Pma = \frac{(100) - (5.0)}{1.00 + [(0.01) \times (2.0)]} = 93.14 \qquad Pmx = [100 - (5.0)] - (93.14) = 1.86$$

$$Vag = \frac{(93.14) \times (2.294)}{(2.576)} = 82.94 \qquad Vmx = \frac{(1.86) \times (2.294)}{(3.14)} = 1.36$$

$$Pbe = (5.0) - [(0.59) \times (93.14) \times (0.01)] = 4.45 \qquad Vbe = \frac{(4.45) \times (2.294)}{(1.023)} = 9.98$$

$$VMA = 100 - (82.94) - (1.36) = 15.70 \qquad EV = (15.70) - (9.98) = 5.72 \qquad VF = \frac{(9.98)}{(15.70)} \times 100 = 63.57$$

Pb = 5.5 %

$$Pma = \frac{(100) - (5.5)}{1.00 + [(0.01) \times (2.0)]} = 92.65 \qquad Pmx = [100 - (5.5)] - (92.65) = 1.85$$

$$Vag = \frac{(92.65) \times (2.316)}{(2.576)} = 83.30 \qquad Vmx = \frac{(1.85) \times (2.316)}{(3.14)} = 1.36$$

$$Pbe = (5.5) - [(0.59) \times (92.65) \times (0.01)] = 4.95 \qquad Vbe = \frac{(4.95) \times (2.316)}{(1.023)} = 11.21$$

$$VMA = 100 - (83.30) - (1.36) = 15.34 \qquad EV = (15.34) - (11.21) = 4.13 \qquad VF = \frac{(11.21)}{(15.34)} \times 100 = 73.08$$

Pb = 4.6 %: Interpolated Gmb = 2.275 ; Gmb x 62.3 = (2.275) x 62.3 = 141.7 lb./cu. ft.

$$Pma = \frac{(100) - (4.6)}{1.00 + [(0.01) \times (2.0)]} = 93.53 \qquad Pmx = [100 - (4.6)] - (93.53) = 1.87$$

$$Vag = \frac{(93.53) \times (2.275)}{(2.576)} = 82.60 \qquad Vmx = \frac{(1.87) \times (2.275)}{(3.14)} = 1.35$$

$$Pbe = (4.6) - [(0.59) \times (93.53) \times (0.01)] = 4.05 \qquad Vbe = \frac{(4.05) \times (2.275)}{(1.023)} = 9.01$$

$$VMA = 100 - (82.60) - (1.35) = 16.05 \qquad EV = (16.05) - (9.01) = 7.04 \qquad VF = \frac{(9.01)}{(16.05)} \times 100 = 56.14$$

Pb = 4.7 %: Interpolated Gmb = 2.280 ; Gmb x 62.3 = (2.280) x 62.3 = 142.0 lb./cu. ft.

$$Pma = \frac{(100) - (4.7)}{1.00 + [(0.01) \times (2.0)]} = 93.43 \qquad Pmx = [100 - (4.7)] - (93.43) = 1.87$$

$$Vag = \frac{(93.43) \times (2.280)}{(2.576)} = 82.69 \qquad Vmx = \frac{(1.87) \times (2.280)}{(3.14)} = 1.36$$

$$Pbe = (4.7) - [(0.59) \times (93.43) \times (0.01)] = 4.15 \qquad Vbe = \frac{(4.15) \times (2.280)}{(1.023)} = 9.25$$

$$VMA = 100 - (82.69) - (1.36) = 15.95 \qquad EV = (15.95) - (9.25) = 6.70 \qquad VF = \frac{(9.25)}{(15.95)} \times 100 = 57.99$$

FIGURE 9

†● 44-2901 R7/81

☐ INITIAL ☐ FINAL ☐ ____________

MATERIALS SECTION
LABORATORY BITUMINOUS MIXTURE DESIGN

Pit No. NORTH POLE S & R
Blend CANDY CANE WASH
Asphalt Source NORTH SLOPE

Received	8-13-85	Test Commenced	8-13-85	Material	1/2" AC
Identification		Sampled	8-12-85	Lab. No.	85-999 B
Submitted by		Sampled by	ELVES	Project No	F-099-9(11)
Source of Sample	STOCKPILES			Quantity	
Location of Supply	NORTH POLE SAND AND ROCK / CANDY CANE WASH				
Project Name	CHRISTMAS CANYON - CLAUS T.I.			Contractor	REINDEER CONTRACTING
Specifications Governing				Mix Design Request No.	2

	MATERIALS SURVEY (PE) PRELIMINARY DESIGN GRADING						~~AS PRODUCED (CONSTRUCTION)~~ ~~FINAL ADJUSTED DESIGN GRADING~~				
	ORIG. PIT AVERAGE		CRUSHED GRADATION		ADJ. CRUSH GRADATION		~~AS CRUSHED ON PROJECT~~ COMPOSITE		~~AS ADJ. IN LABORATORY~~ COMPOSITE		SPEC. LIMITS
Sieve	% Ret	% Pass	% Ret	% Pass	% Ret	% Pass	COARSE	26%	COARSE	25%	
3" Slot							INTER	12%	INTER	12%	
3"							FINE	47%	FINE	46%	
2½"							BLEND	15%	BLEND	15%	
2"								%	CEMENT	2%	
1½"							% Ret	% Pass	% Ret	% Pass	
1"											
¾"								100		100	100
½"							4	96	4	96	90-100
⅜"							18	78	18	78	70-85
¼"							12	66	11	67	
No. 4							7	59	7	60	
8							13	46	13	47	44-52
10							3	43	3	44	
16							7	36	7	37	
30							11	25	11	26	
40							6	19	5	21	13-23
50							5	14	5	16	
100							6	8	6	10	
200							3	4.6	4	6.5	3.0-7.5

O.D. SP. GR. COARSE	2.558	O.D. SP. GR. FINE	2.589	O.D. SP. GR. COMB.	2.576
S.S.D. SP. GR. COARSE	2.597	S.S.D. SP. GR. FINE	2.626	S.S.D. SP. GR. COMB.	2.614
APP. SP. GR. COARSE	2.661	APP. SP. GR. FINE	2.688	APP. SP. GR. COMB.	2.677
ABSORP. COARSE AGGR.	1.51 %	ABSORP. FINE AGGR.	1.43 %	ABSORP. COMB. AGGR	1.48 %

	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	SAND EQUIV.
NATURAL FINES				
CRUSHED FINES				
COMBINED FINES				67

ABRASION (A, B, C, D): 100 REV. 4 % LOSS 500 REV. 18 % LOSS CRUSH.FACES 94 % LIMESTONE %

REMARKS THIS DESIGN REQUIRES THE USE OF 2% TYPE II CEMENT, BY WEIGHT OF AGGREGATE.

O.D. FINE SPECIFIC GRAVITY - NORTH POLE S&R = 2.576
O.D. FINE SPECIFIC GRAVITY - CANDY CANE WASH = 2.629

DESIGN DATA
(SEE BACK FOR CHARTS)

SPECIMEN	A	B	C	D	E	F	DESIGN SPEC.
BIT. GRADE/SPECIFIC. GRAVITY	AC 40 - 1.023						
% OF BIT.	4.5	4.6	5.0	5.5			
BULK DENSITY LBS. PER CU. FT.	141.4	141.7	142.9	144.3			
MARSHALL STABILITY	3953		4338	4441			2000 MIN.
FLOW	11		12	12			8-16
HVEEM STABILITY							
COHESION							
% AIR VOIDS	7.4	7.0	5.7	4.1			5.0-7.0
% V.M.A.	16.1	16.0	15.7	15.3			15.5-18.5
% AIR VOIDS FILLED	54.3	56.1	63.6	73.1			
% EFFECT ASPHALT TOTAL MIX	3.95	4.05	4.45	4.95			

SAMPLE	AIR PSI	H_2O PSI	RETENTION	ARIZ 802 MINIMUM RETENTION 50 % H_2O PSI MINIMUM 150
No. 1			%	4.6 % AC 40 ASPHALT
No. 2	854	539	63 %	2.0 % TYPE II CEMENT
No. 3			%	%
No. 4			%	%
No. 5			%	%
No. 6			%	%

MAX. DENSITY 152.4 LBS. PER CU. FT @ 4.6 % ~~ARIZ 806 (RICE TEST)~~

ASPHALT ABSORP. ON DRY AGGREGATE 0.59 %

AGG. SURFACE AREA= SQ.FT./LB. FILM THICKNESS MICRONS

C.K.E. VALUES - ARIZ 805 F = F(CORR.)= C = C(CORR)=

Kf = Kc = Km =

BIT GRADE RECOMMENDED BITUMEN %

RECOMMENDED BITUMEN CONTENT CONSIDERING ALL TEST DATA 4.6 %

MIX DESIGN GRADATION TARGET VALUES

Sieve	% Pass W/O CEMENT	W/ CEMENT
1"	100	100
¾"	100	100
½"	96	96
⅜"	78	78
No. 4	–	–
8	46	47
40	19	21
200	4.6	6.5

FIGURE 10

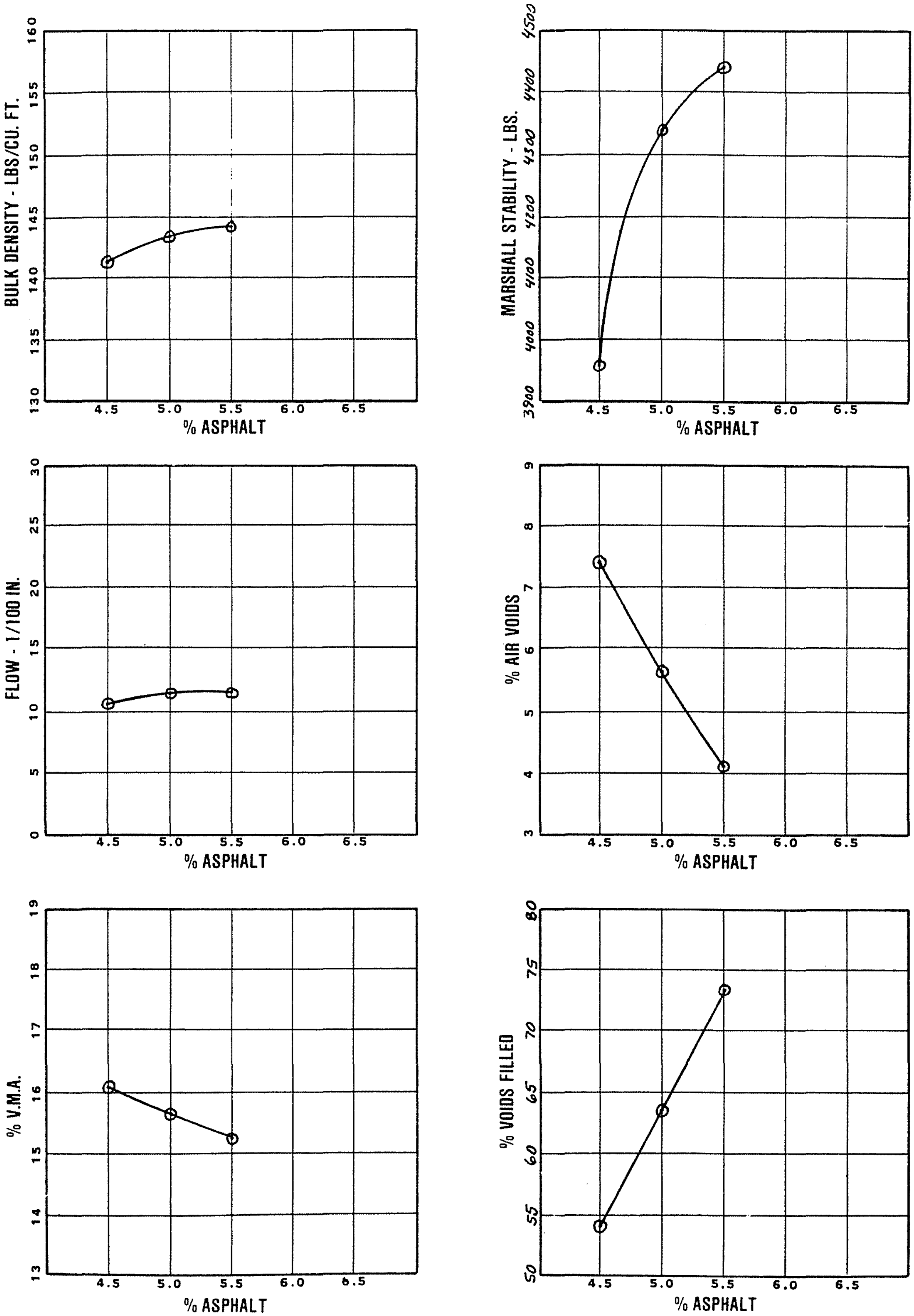
BULK DENSITY - LBS/CU. FT.
130
135
140
145
150
155
160
4.5
5.0
5.5
6.0
6.5
% ASPHALT
MARSHALL STABILITY - LBS.
3900
4000
4100
4200
4300
4400
4500
4.5
5.0
5.5
6.0
6.5
% ASPHALT
FLOW - 1/100 IN.
0
5
10
15
20
25
30
4.5
5.0
5.5
6.0
6.5
% ASPHALT
% AIR VOIDS
3
4
5
6
7
8
9
4.5
5.0
5.5
6.0
6.5
% ASPHALT
% V.M.A.
13
14
15
16
17
18
19
4.5
5.0
5.5
6.0
6.5
% ASPHALT
% VOIDS FILLED
50
55
60
65
70
75
80
4.5
5.0
5.5
6.0
6.5
% ASPHALT

FIGURE 11